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(54) TRANSMISSION DEVICE, RECEPTION DEVICE, AND COMMUNICATION SYSTEM AND REMOTE OPERATING DEVICE EACH INCLUDING TRANSMISSION DEVICE AND RECEPTION DEVICE

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(58) **Field of Classification Search**
CPC G07C 9/00182; G07C 2009/00206; G07C 2009/00769; G07C 2009/00984;
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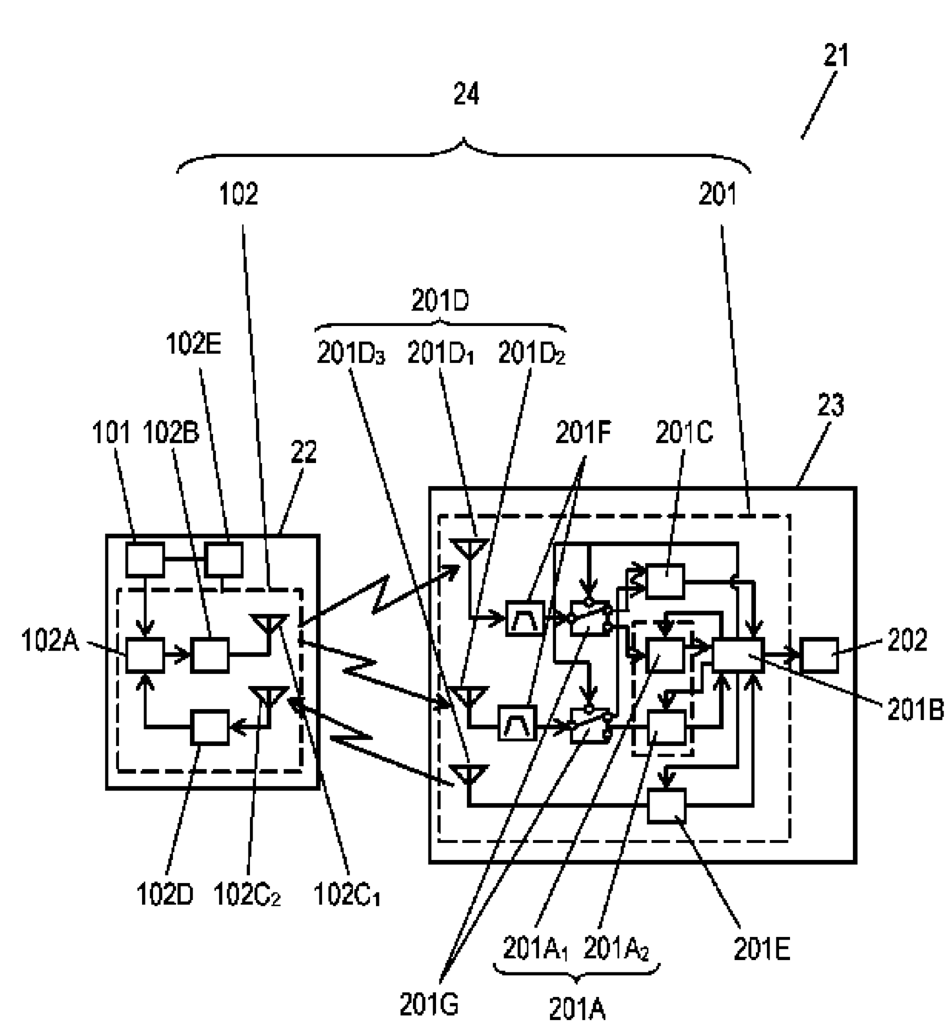
(57) **ABSTRACT**

A transmission device includes a first control unit and a signal transmission unit. The first control unit outputs transmission data. The signal transmission unit receives transmission data, converts the data to a first frequency signal and a second frequency signal, and transmits the signals. The reception device includes a signal reception unit and a second control unit. The signal reception unit outputs a first reception signal based on the first frequency signal, and
(Continued)



outputs a second reception signal based on the second frequency signal. The second control unit outputs a first control signal in a case where at least one the first reception signal or the second reception signal includes the transmission data. A communication system includes a transmission device and a reception device. A remote operating device includes an input unit, a transmission device, a reception device, and a controlled unit.

30 Claims, 6 Drawing Sheets

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H04B 15/00	(2006.01)
G08C 17/02	(2006.01)
G08C 19/14	(2006.01)
G08C 25/00	(2006.01)
H04L 1/18	(2006.01)

(52) **U.S. Cl.**
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See application file for complete search history.

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FIG. 1

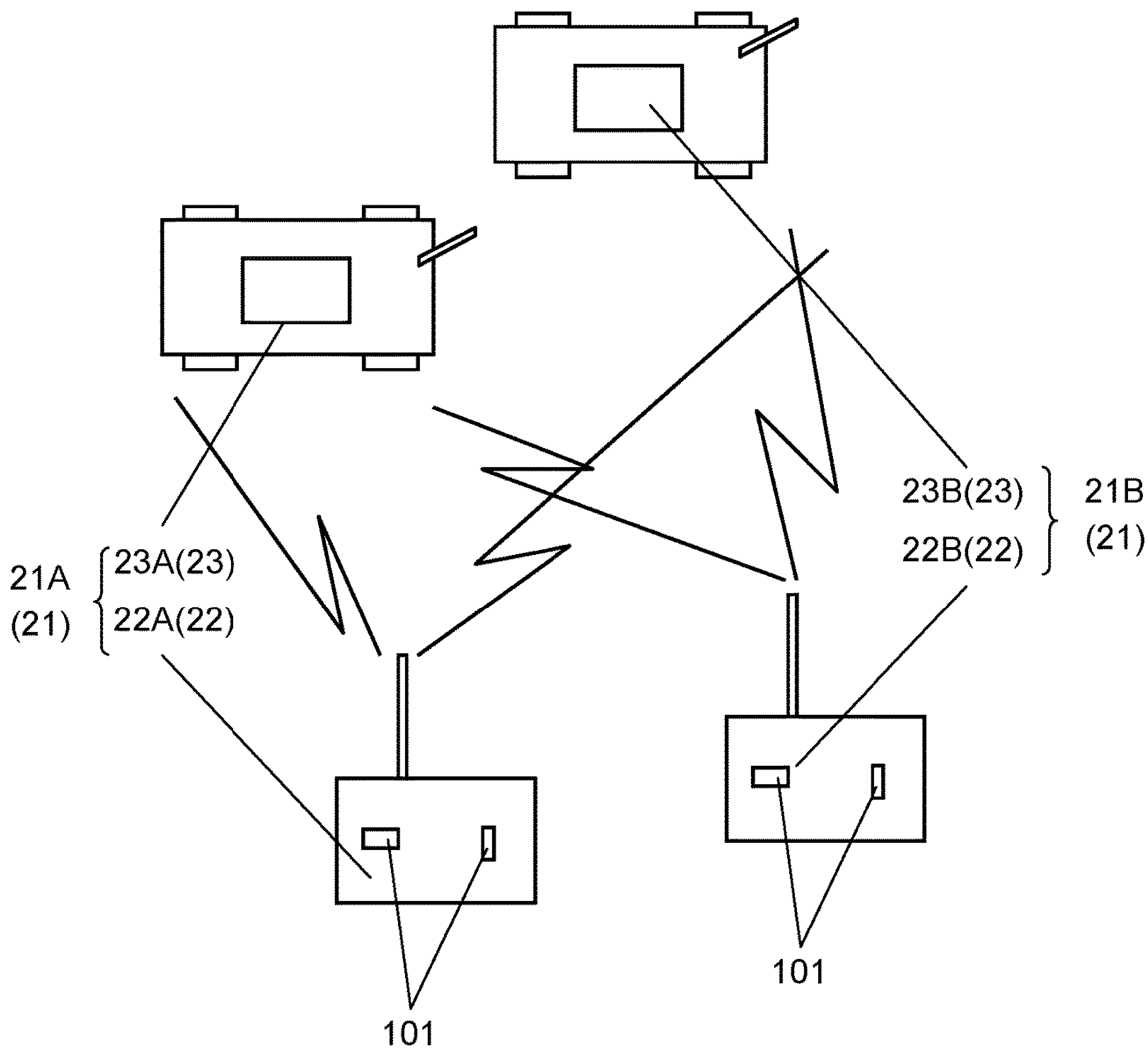


FIG. 2

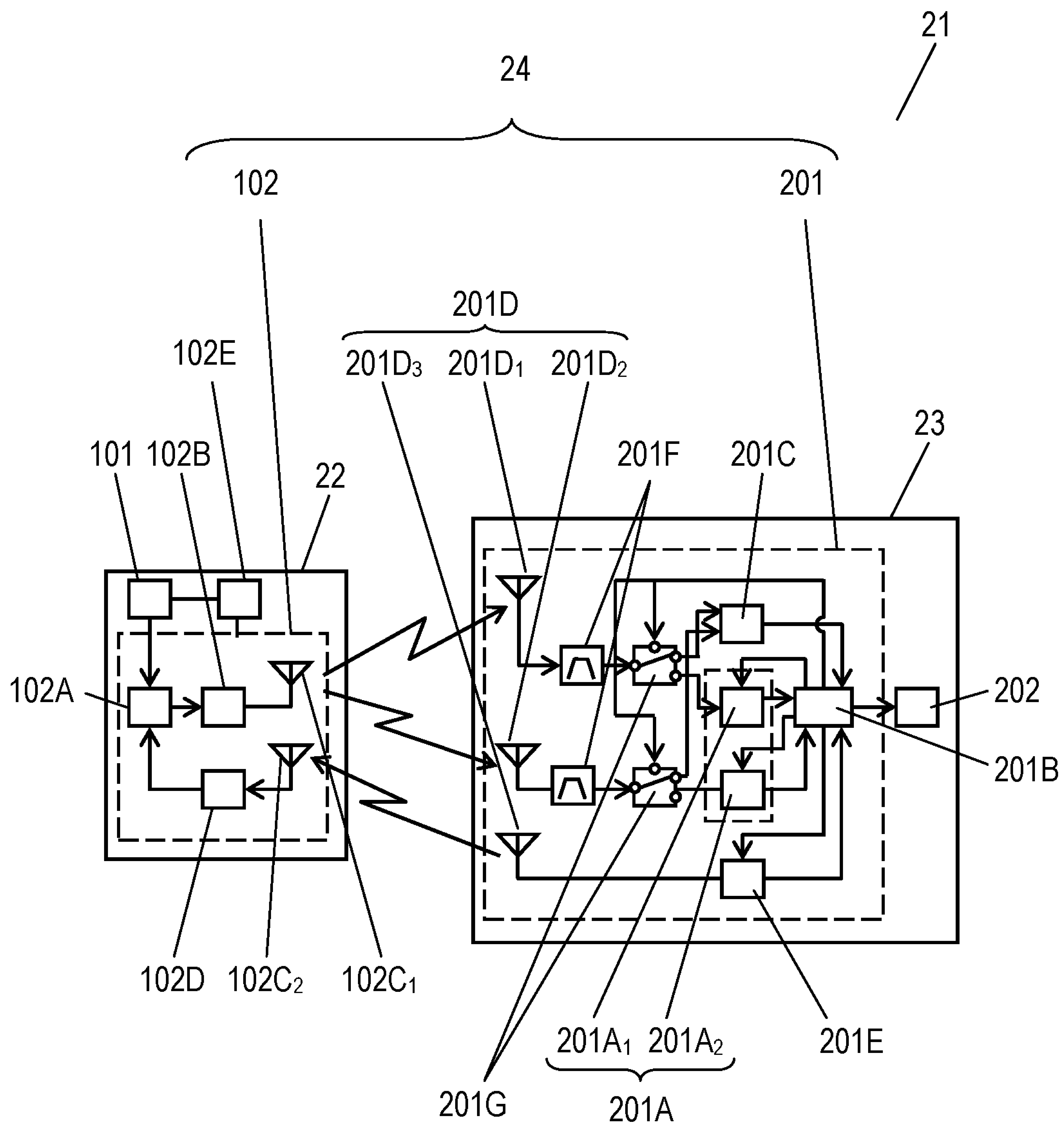

21
24
102
201
201D
201D3 201D1 201D2
102E
101 102B
22
201F
201C
23
102A
202
201B
102D 102C2 102C1
201A1 201A2
201E
201G
201A

FIG. 3

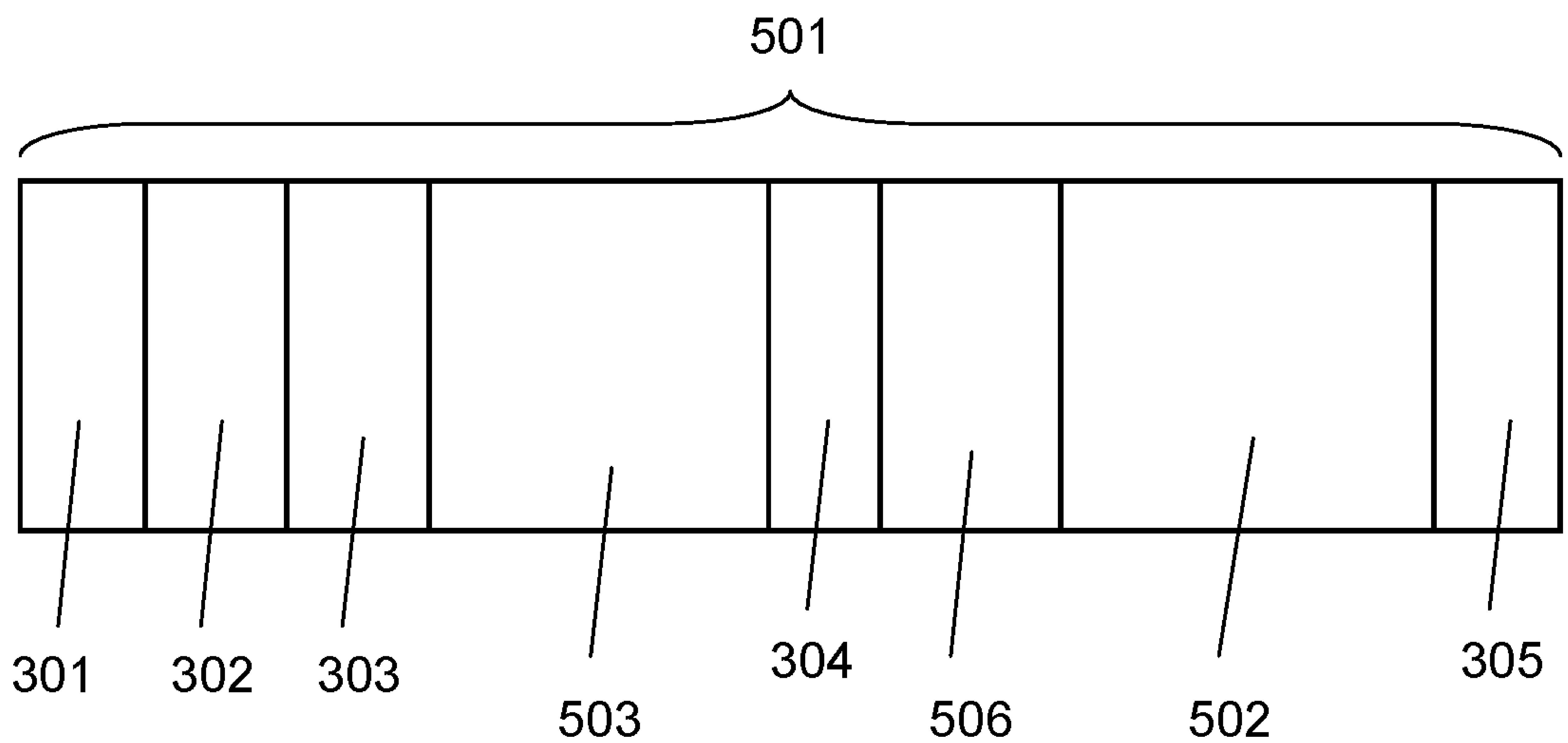
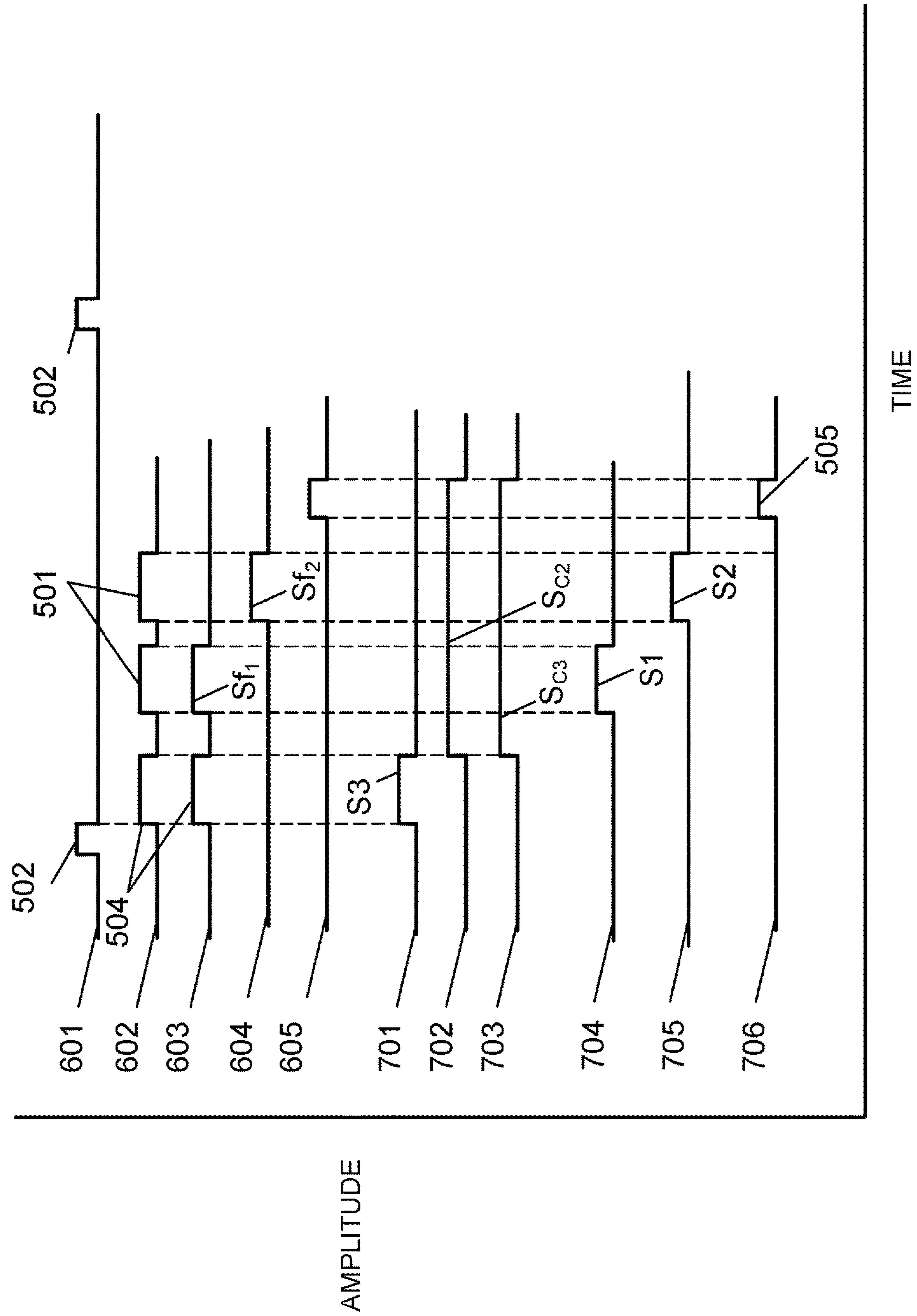


FIG. 4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504
505
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Sf2
S3
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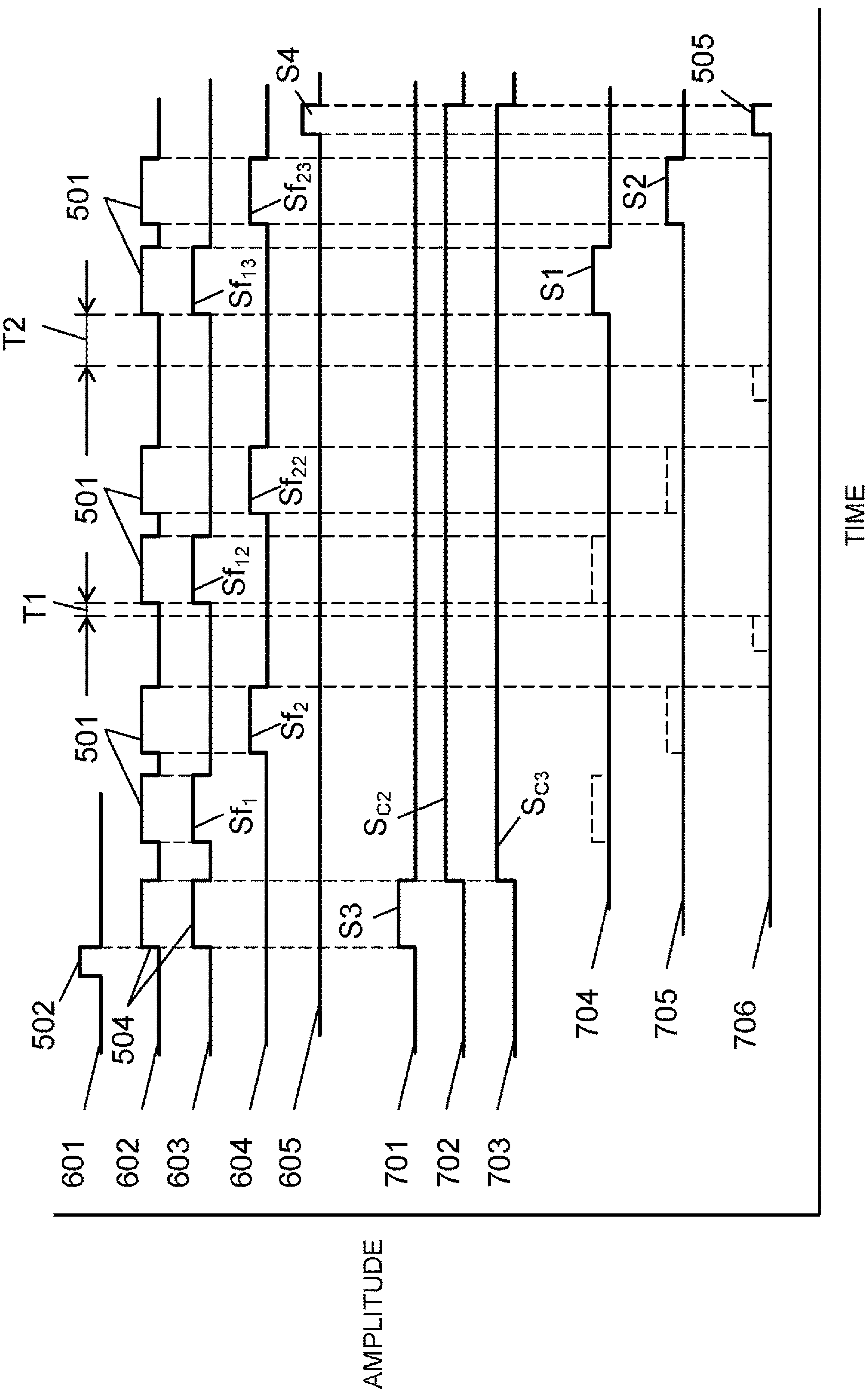
AMPLITUDE
TIME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S4
Sf_1
Sf_2
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Sf_{13}
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Sf_{23}
S_{C2}
S_{C3}
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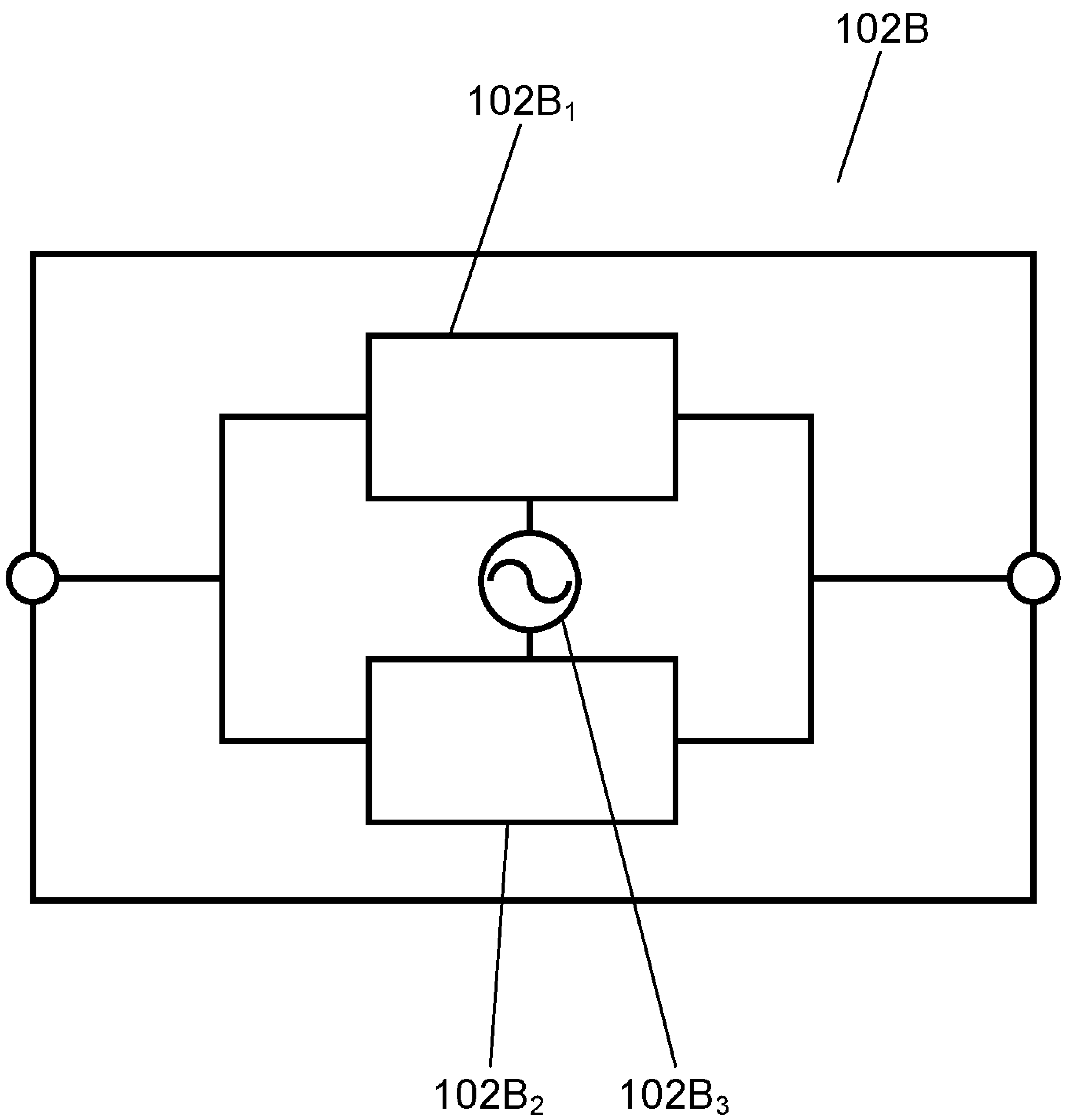
AMPLITUDE
TIME

FIG. 5

FIG. 6



TRANSMISSION DEVICE, RECEPTION DEVICE, AND COMMUNICATION SYSTEM AND REMOTE OPERATING DEVICE EACH INCLUDING TRANSMISSION DEVICE AND RECEPTION DEVICE

This application is a U.S. national stage application of the PCT international application No. PCT/JP2016/000859.

TECHNICAL FIELD

The present disclosure relates to a transmission device that transmits a signal wirelessly, a reception device, and a communication system and a remote operating device each including the transmission device and the reception device.

BACKGROUND ART

A conventional communication system includes a first communication device and a second communication device. The first communication device includes a first control unit, a transmission unit, and an error signal reception unit.

The second communication device includes a second control unit, a reception unit, and a response unit.

The first control unit outputs transmission data to the transmission unit. The transmission unit converts the transmission data output from the first control unit to a first frequency and transmits the converted data to the second communication device (first transmission). The reception unit of the second communication device receives data from the transmission unit. If it is determined that the signal received by the reception unit is not correct transmission data, the second control unit outputs an error signal to the response unit. The response unit converts the error signal from the second control unit to the first frequency and transmits the converted signal to the error signal reception unit of the first communication device. An output of the error signal reception unit is supplied to the first control unit. If the first control unit detects the error signal, the first control unit outputs transmission data again to the transmission unit. Then, the transmission unit performs second transmission. The first control unit outputs the transmission data again after a lapse of a random backoff time after outputting an error signal.

Patent Literature 1, for example, is known as prior art information related to this application.

CITATION LIST

Patent Literature

PTL 1: Japanese Unexamined Patent Application Publication No. 6-29978

SUMMARY

A transmission device (first communication device) according to the present disclosure includes a first control unit and a signal transmission unit.

The first control unit outputs transmission data including an identification signal.

The signal transmission unit receives the transmission data, converts the data to a first frequency signal and a second frequency signal having a frequency different from that of the first frequency signal, and transmits the first and second frequency signals.

A reception device (second communication device) according to the present disclosure includes a signal reception unit and a second control unit.

The signal reception unit receives the first frequency signal and the second frequency signal, outputs a first reception signal based on the first frequency signal, and outputs a second reception signal based on the second frequency signal.

The second control unit receives the first reception signal and the second reception signal, outputs a first control signal in a case where at least one the first reception signal or the second reception signal includes the transmission data.

A communication system according to the present disclosure includes a transmission device (first communication device) and a reception device (second communication device).

A remote operating device according to the present disclosure includes an input unit, a transmission device (first communication device), a reception device (second communication device), and a controlled unit.

The transmission device (first communication device) includes a first control unit and a signal transmission unit.

The first control unit outputs transmission data including an identification signal based on an instruction signal input from the input unit.

The signal transmission unit receives the transmission data, converts the data to a first frequency signal and a second frequency signal having a frequency different from that of the first frequency signal, and transmits the first and second frequency signals.

The reception device (second communication device) includes a signal reception unit and a second control unit.

The signal reception unit receives the first frequency signal and the second frequency signal, outputs a first reception signal based on the first frequency signal, and outputs a second reception signal based on the second frequency signal.

The second control unit receives the first reception signal and the second reception signal, and outputs a first control signal to the controlled unit in a case where at least one the first reception signal or the second reception signal includes the transmission data.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a conceptual view of a remote operating device according to an exemplary embodiment.

FIG. **2** is a block diagram of the remote operating device according to the exemplary embodiment.

FIG. **3** illustrates the content of transmission data in the exemplary embodiment.

FIG. **4** is a timing chart concerning an operation of a communication system according to the exemplary embodiment.

FIG. **5** is a timing chart concerning another operation of the communication system according to the exemplary embodiment.

FIG. **6** is a block diagram of a signal transmission unit according to the exemplary embodiment.

DESCRIPTION OF EMBODIMENT

In a conventional reception unit, if transmission data that is transmitted at the first time is not correctly received, the transmission data is transmitted again after a lapse of a backoff time. The backoff time, however, is set at random in order to be shifted from the timing of transmission from another communication system. Thus, a receiver needs to continue a reception state until reception of transmission data transmitted at the second time is completed after a lapse of the longest backoff time. Accordingly, a period during which the receiver is activated increases. Consequently, power consumption of the receiver increases.

Prior to description of a remote operating device according to an exemplary embodiment, a remote operating device will be described. The remote operating device includes an operating device with which an operator performs an operation and an operated device controlled in accordance with the operation of the operating device with wireless communication. The remote operating device is, for example, a model that is wirelessly controlled. The wirelessly controlled model may be an automobile, for example, or a yacht or other objects. In such cases, the operating device and the operated device are separated from each other. The remote operating device is not limited to such wirelessly controlled models, and may be a bicycle, for example. In this case, both the operating device and the operated device are mounted on a frame of the bicycle, for example.

In some cases, a plurality of remote operating devices operate at the same time. For example, in a contest of radio-controlled cars, multiple radio-controlled cars run at the same time. At this time, many of the radio-controlled cars perform similar wireless communication. Thus, a radio-controlled car operated by a person might be interfered with wireless communication of a radio-controlled car operated by another person. In the case of such interference, the radio-controlled car might be inoperative or an operation of the radio-controlled car might be delayed. In view of this, a remote operating device needs to suppress occurrence of interference with another remote operating device or communication of another wireless equipment.

Such an operated device is movable. Thus, at least the operated device has difficulty in continuously receiving electric power from a general commercial power supply. In a case where the remote operating device is a bicycle, for example, the operating device also has difficulty in receiving electric power from a commercial power supply. Thus, the remote operating device needs to operate with electric power from a power supply except a commercial power supply, such as a battery, a storage battery, or a self-contained power generator. Note that each of the operating device and the operated device does not need to always operate with electric power from a power supply except a commercial power supply, and only needs to have a configuration that enables operation with a power supply except a commercial power supply. Each of the operating device and the operated device is not limited to a movable configuration, and may be used while being installed at a predetermined place. As described above, the remote operating device operates with limited electric power. In particular, the amount of electric power generated by a self-contained power generator is small. Thus, electric power consumed by the remote operating device is preferably small. That is, a time necessary for communication is preferably short. A standby time in a case where transmission data transmitted at the first time is not correctly received is preferably short. In addition, in a case where a plurality of remote operating devices operate at the same time, these remote operating devices preferably do not interfere with each other.

Exemplary Embodiment

A transmission device (first communication device **102**), a reception device (second communication device **201**), communication system **24**, and remote operating device **21** will be described hereinafter with reference to the drawings. FIG. **1** is a conceptual view of remote operating device **21**. FIG. **2** is a block diagram of remote operating device **21**. FIG. **3** illustrates the content of transmission data **501**. Transmission data **501** includes instruction signal **502** and identification signal **503**. Transmission data **501** may further include preamble **301**, sync signal **302**, control signal **303**, retransmission number signal **304**, error detection signal **305**, and operation number signal **506**.

In the present embodiment, as illustrated in FIG. **1**, remote operating device **21**A and remote operating device **21**B will be described as examples. Here, remote operating device **21**A and remote operating device **21**B are both radio-controlled cars. Remote control device **21**A includes operating device **22**A and operated device **23**A. Remote control device **21**B includes operating device **22**B and operated device **23**B. Remote control device **21**A and remote operating device **21**B have different identification numbers, but have the same configuration. Thus, description will be given on remote operating device **21** as a representative of remote operating device **21**A and remote operating device **21**B.

Remote control device **21** includes operating device **22** and operated device **23**. Operating device **22** includes input unit **101** and first communication device **102** (transmission device). Operated device **23** includes second communication device **201** (reception device) and controlled unit **202**. Communication system **24** includes a first communication device **102** (transmission device) and a second communication device **201** (reception device). An output of second communication device **201** is supplied to controlled unit **202**. Controlled unit **202** is, for example, a motor or a gear. Remote control device **21** includes input unit **101**, first communication device **102**, second communication device **201**, and controlled unit **202**. In the foregoing configuration, an operator (not shown) operates input unit **101**. In response to the operation of the operator, input unit **101** outputs an instruction signal **502** illustrated in FIG. **3**. In a case where operating device **22** operates with a self-contained power generator **102**E, power generator **102**E generates charge with an operation of input unit **101**. Power generator **102**E can generate power with, for example, an electromagnet or a piezoelectric element.

Remote control device **21** stores a unique identification number. That is, remote operating device **21**A and remote operating device **21**B illustrated in FIG. **1** have different identification numbers. Identification signal **503** illustrated in FIG. **3** corresponds to an identification number. Based on instruction signal **502** input from input unit **101**, first control unit **102**A outputs transmission data **501** including identification signal **503** and instruction signal **502**.

Transmission data **501** includes identification signal **503** corresponding to an identification number. The identification number is, for example, a number unique to, for example, a communication system, an operating device, or an operated device. The identification number may be a permanently fixed number. The identification number may be, for example, a serial number provided in a fabrication process of, for example, a communication system, an operating device, or an operated device. Alternatively, the identification number may be, for example, a number assigned to, for example, a communication system, an operating device, or an operated device in a contest or other situations.

Transmission data **501** is transmitted from first communication device **102** to second communication device **201**. Based on identification signal **503**, operated device **23** determines whether instruction signal **502** is a signal received from operating device **22** with which operated device **23** should communicate. Second communication device **201** that received instruction signal **502** outputs a first control signal based on instruction signal **502** to controlled unit **202**. Through these operations, the operator can operate operated device **23** with wireless communication.

First communication device **102** will now be specifically described.

First communication device **102** includes first control unit **102**A and signal transmission unit **102**B. An output of input unit **101** is supplied to first control unit **102**A. First control unit **102**A outputs transmission data **501** illustrated in FIG. **3** to signal transmission unit **102**B. That is, transmission data **501** serves as an input signal of signal transmission unit **102**B. Signal transmission unit **102**B converts the input signal to first frequency signal Sf_1 with first frequency f_1 and second frequency signal Sf_2 with second frequency f_2 different from that of first frequency signal Sf_1. Here, signal transmission unit **102**B may start transmission of second frequency signal Sf_2 after starting transmission of first frequency signal Sf_1. Alternatively, signal transmission unit **102**B may transmit second frequency signal Sf_2 after completing transmission of first frequency signal S_1. That is, signal transmission unit **102**B transmits transmission data **501** using two frequencies. Both first frequency signal Sf_1 and second frequency signal Sf_2 are high frequency signals. First frequency f_1 and second frequency f_2 may be in, for example, a 2.4 GHz band.

On the other hand, second communication device **201** includes signal reception unit **201**A and second control unit **201**B. Signal reception unit **201**A receives first frequency signal Sf_1 and outputs first reception signal S_1. Signal reception unit **201**A receives second frequency signal Sf_2 and outputs second reception signal S_2. An output of signal reception unit **201**A is supplied to second control unit **201**B. That is, first reception signal S_1 and second reception signal S_2 are supplied to second control unit **201**B. If it is determined that at least one of first reception signal S_1 or second reception signal S_2 includes identification signal **503**, second control unit **201**B outputs first control signal Sc_1 corresponding to instruction signal **502** to controlled unit **202**.

Communication system **24** and remote operating device **21** according to the present embodiment will now be more specifically described. As illustrated in FIG. **2**, signal transmission unit **102**B may include antenna **102**C_1. First frequency signal Sf_1 and second frequency signal Sf_2 output from signal transmission unit **102**B are transmitted through antenna **102**C_1. Antenna **102**C_1 can preferably transmit first frequency signal Sf_1 and second frequency signal Sf_2. Since one antenna **102**C_1 transmits first frequency signal Sf_1 and second frequency signal Sf_2, the size of first communication device **102** can be reduced. Antenna **102**C_1 is not limited to the configuration that transmits first frequency signal Sf_1 and second frequency signal Sf_2, and may be configured as an antenna (not shown) for transmitting first frequency signal Sf_1 and an antenna (not shown) for transmitting second frequency signal Sf_2 separately.

Signal transmission unit **102**B converts transmission data **501** to two frequencies of first frequency f_1 and second frequency f_2, and transmits the converted signals. However, the present disclosure is not limited to this configuration, and the data may be converted to three or more frequencies for transmission. In such a configuration, signal reception unit **201**A can also receive the entire frequency band of a signal transmitted from signal transmission unit **102**B.

As illustrated in FIG. **2**, second communication device **201** may include antenna **201**D that receives first frequency signal Sf_1 and second frequency signal Sf_2. Antenna **201**D receives first frequency signal Sf_1 and second frequency signal Sf_2, and outputs first frequency signal Sf_1 and second frequency signal Sf_2 to signal reception unit **201**A.

Signal reception unit **201**A may include first receiver **201**A_1 and second receiver **201**A_2. First receiver **201**A_1 receives first frequency signal Sf_1 and outputs first reception signal S_1. Second receiver **201**A_2 receives second frequency signal Sf_2 and outputs second reception signal S_2. In this case, antenna **201**D may include antenna **201**D_1 and antenna **201**D_2. For example, antenna **201**D_1 may receive first frequency signal Sf_1 with antenna **201**D_2 receiving second frequency signal Sf_2. A signal received by antenna **201**D_1 may be supplied to first receiver **201**A_1 with a signal received by antenna **201**D_2 being supplied to second receiver **201**A_2.

Signal transmission unit **102**B preferably includes a first transmitter (not shown) for transmitting first frequency signal Sf_1 and a second transmitter (not shown) for transmitting second frequency signal Sf_2. With this configuration, in signal transmission unit **102**B, a period from transmission of first frequency signal Sf_1 to transmission of second frequency signal Sf_2 can be shortened. That is, signal reception unit **201**A can shorten the time necessary for receiving first frequency signal Sf_1 and second frequency signal Sf_2. Specifically, signal transmission unit **102**B can transmit second frequency signal Sf_2 before completing transmission of first frequency signal Sf_1. Signal reception unit **201**A can receive second frequency signal Sf_2 before completing reception of first frequency signal Sf_1. Thus, the period in which signal reception unit **201**A is activated can be shortened so that power consumption of second communication device **201** can be reduced.

Second communication device **201** preferably further includes activation signal detector **201**C. Start signal detector **201**C preferably can receive both first frequency signal Sf_1 and second frequency signal Sf_2. FIG. **4** is a timing chart concerning an operation of communication system **24**.

In FIG. **4**, signal **601** is a signal output from input unit **101**. Signal **602** is a signal output from first control unit **102**A. Signal **603** is a signal with first frequency f_1 output from signal transmission unit **102**B. Signal **604** is a signal with second frequency f_2 output from signal transmission unit **102**B. Signal **605** is a signal output from third receiver **102**D. Signal **701** is a signal output from activation signal detector **201**C. Signal **702** is second control signal Sc_2 output from second control unit **201**B. Signal **703** is third control signal Sc_3 output from second control unit **201**B. Signal **704** and signal **705** are signals output from signal reception unit **201**A illustrated in FIG. **2**. Signal **706** is a signal output from reply unit **201**E.

First control unit **102**A outputs activation signal **504** illustrated in FIG. **4** to signal transmission unit **102**B. After outputting activation signal **504**, first control unit **102**A outputs transmission data **501** to signal transmission unit **102**B. When detecting activation signal **504**, activation signal detector **201**C outputs third reception signal S_3 to second control unit **201**B. When receiving third reception signal S_3, second control unit **201**B supplies second control signal Sc_2 to signal reception unit **201**A. In response to second control signal Sc_2, signal reception unit **201**A is activated. That is, signal reception unit **201**A can be activated based on activation signal **504**. Since signal reception unit **201**A is not activated until activation signal **504** is input, power electric power consumed by reception unit **201**A can be reduced.

In a case where signal reception unit **201**A includes first receiver **201**A_1 and second receiver **201**A_2, second control signal Sc_2 is supplied to both first receiver **201**A_1 and second receiver **201**A_2. First receiver **201**A_1 and second receiver **201**A_2 are activated in response to second control signal Sc_2. Since first receiver **201**A_1 and second receiver **201**A_2 are activated in response to activation signal **504**, power consumption of first receiver **201**A_1 and second receiver **201**A_2 can be reduced.

Preferably, antenna **201**D_1 receives both first frequency signal Sf_1 and second frequency signal Sf_2, and antenna **201**D_2 receives second frequency signal Sf_2. With this configuration, antennas can be shared so that the size of second communication device **201** can be reduced. In addition, the number of components can be reduced so that productivity can be enhanced. As a result, communication system **24** can be obtained at low cost. In this case, a signal received by antenna **201**D_1 is supplied to activation signal detector **201**C and first receiver **201**A_1. A signal received by antenna **201**D_2 is supplied to second receiver **201**A_2. The present disclosure, however, is not limited to the configuration described above, and antenna **201**D_2 may receive both first frequency signal Sf_1 and second frequency signal Sf_2 with antenna **201**D_1 receiving first frequency signal Sf_1. In this case, the signal received by antenna **201**D_2 is supplied to activation signal detector **201**C and second receiver **201**A_2. On the other hand, the signal received by antenna **201**D_1 is supplied to first receiver **201**A_1. Alternatively, antenna **201**D_1 may receive first frequency signal Sf_1 with antenna **201**D_2 receiving second frequency signal Sf_2. In this case, first frequency signal Sf_1 received by antenna **201**D_1 is supplied to activation signal detector **201**C. On the other hand, second frequency signal Sf_2 received by antenna **201**D_2 is supplied to second receiver **201**A_2 and activation signal detector **201**C. Alternatively, an antenna (not shown) dedicated to activation signal detector **201**C may be provided.

Start signal detector **201**C does not necessarily receive both first frequency signal Sf_1 and second frequency signal Sf_2, and may receive one of first frequency signal Sf_1 or second frequency signal Sf_2. For example, in a case where activation signal detector **201**C can receive only first frequency signal Sf_1, signal reception unit **201**A transmits activation signal **504** illustrated in FIG. **4** only at first frequency f_1. In this case, antenna **201**D_1 receives first frequency signal Sf_1, and supplies received first frequency signal Sf_1 to activation signal detector **201**C and first receiver **201**A_1. On the other hand, antenna **201**D_2 receives second frequency signal Sf_2, and supplies received second frequency signal Sf_2 to second receiver **201**A_2. Alternatively, in a case where activation signal detector **201**C receives only second frequency signal Sf_2, antenna **201**D_2 receives second frequency signal Sf_2, and supplies received second frequency signal Sf_2 to activation signal detector **201**C and second receiver **201**A_2.

Second communication device **201** preferably includes reply unit **201**E. In this case, first communication device **102** includes third receiver **102**D. Reply unit **201**E may include antenna **201**D_3. Third receiver **102**D may include antenna **102**C_2. A signal output from reply unit **201**E is supplied to antenna **201**D_3. A signal received by antenna **102**C_2 is supplied to third receiver **102**D. In a case where it is determined that at least one of first reception signal S_1 or second reception signal S_2 includes identification signal **503**, second control unit **201**B outputs, to reply unit **201**E, reply signal **505** indicating that instruction signal **502** is correctly received. Reply unit **201**E transmits reply signal **505** to third receiver **102**D. An output of third receiver **102**D is supplied to first control unit **102**A.

With this configuration, first control unit **102**A can determine that transmission data **501** is correctly transmitted. In this case, retransmission of transmission data **501** is unnecessary. Thus, in the case of detecting reply signal **505**, first control unit **102**A stops retransmission of transmission data **501**. With this configuration, occurrence of interference with another communication system can be suppressed. Alternatively, first control unit **102**A may stop an operation of signal transmission unit **102**B in the case of detecting reply signal **505**. This configuration can reduce power consumption of first communication device **102**. In addition, after transmitting reply signal **505**, second control unit **201**B can stop an operation of reply unit **201**E. Thus, power consumption of second communication device **201** can be further reduced.

Reply unit **201**E preferably converts reply signal **505** to third frequency signal Sf_3 with a third frequency different from first frequency f_1 and second frequency f_2. In this case, third receiver **102**D receives third frequency signal Sf_3, and outputs fourth reception signal S_4 (reply receipt signal) to first control unit **102**A. In a case where it is determined that fourth reception signal includes reply signal **505**, first control unit **102**A determines that transmission data **501** is correctly transmitted. With this configuration, occurrence of interference in signal reception unit **201**A can be suppressed in transmitting reply signal **505** to first communication device **102**. That is, since instruction signal **502** and reply signal **505** have different frequencies, it is possible to suppress interference of instruction signal **502** with reply signal **505**. Since third frequency signal Sf_3 obtained by modifying reply signal **505** has a frequency different from those of first frequency signal Sf_1 and second frequency signal Sf_2 obtained by modifying an instruction signal, occurrence of interference among these signals can be suppressed.

Second communication device **201** preferably includes filter **201**F. First frequency signal Sf_1 and second frequency signal Sf_2 pass through filter **201**F. However, filter **201**F attenuates third frequency signal Sf_3. As a result, it is possible to prevent third frequency signal Sf_3 from entering signal reception unit **201**A and activation signal detector **201**C. With this configuration, interference of instruction signal **502** with reply signal **505** can be suppressed. In addition, it is possible to reduce a problem that activation signal detector **201**C malfunctions because of third frequency signal Sf_3 to cause reply signal **505** to be erroneously determined as activation signal **504**. Filter **201**F is provided between antenna **201**D_1 and signal reception unit **201**A or between antenna **201**D_2 and signal reception unit **201**A.

Second communication device **201** preferably includes switch **201**G. A signal received by antenna **201**D is supplied to switch **201**G. A signal output from a first output terminal of switch **201**G is supplied to activation signal detector **201**C. A signal output from a second output terminal of switch **201**G is supplied to signal reception unit **201**A. Switch **201**G is switched by supplying third control signal Sc_3 output from second control unit **201**B to a connection switching terminal (not shown). In the case of detecting activation signal **504**, second control unit **201**B outputs third control signal Sc_3. Based on third control signal Sc_3, switch **201**G switches connection from a first output terminal to a second output terminal. That is, in the case where second control unit **201**B detects activation signal **504**, one or both of first frequency signal Sf_1 and second frequency signal Sf_2 is supplied to signal reception unit **201**A.

FIG. **4** illustrates a case where second control unit **201**B illustrated in FIG. **2** can detect identification signal **503** at one communication operation. Input unit **101** outputs instruction signal **502** illustrated in FIG. **4** by an operation of an operator with input unit **101**. First control unit **102**A receives instruction signal **502** from input unit **101** and then outputs activation signal **504** to signal transmission unit **102**B. Signal transmission unit **102**B converts activation signal **504** to a first frequency signal or a second frequency signal and transmits the converted signal to second communication device **201**. At this time, signal reception unit **201**A does not operate, and activation signal detector **201**C has been activated. Switch **201**G allows one or both of first frequency signal Sf_1 and second frequency signal Sf_2 to be supplied to activation signal detector **201**C. Start signal detector **201**C receives the first frequency signal or the second frequency signal, and outputs third reception signal S_3 illustrated in FIG. **4** to second control unit **201**B. Third reception signal S_3 is generated in accordance with first frequency signal Sf_1 or second frequency signal Sf_2. Based on third reception signal S_3, second control unit **201**B outputs second control signal Sc_2 illustrated in FIG. **4** to signal reception unit **201**A. As a result, signal reception unit **201**A is activated in response to second control signal Sc_2.

At this time, second control unit **201**B supplies third control signal Sc_3 illustrated in FIG. **4** to the connection switching terminal of switch **201**G. With this configuration, switch **201**G is switched to supply first frequency signal Sf_1 or second frequency signal Sf_2 to signal reception unit **201**A. As a result, first frequency signal Sf_1 or second frequency signal Sf_2 is input to signal reception unit **201**A.

Start signal detector **201**C is preferably configured to output third reception signal S_3 in a case where input first frequency signal Sf_1 or second frequency signal Sf_2 is at a predetermined level (amplitude) or more. In this case, activation signal detector **201**C is constituted by, for example, a demodulator. Thus, power consumption of activation signal detector **201**C can be reduced.

With this configuration, second control unit **201**B can activate signal reception unit **201**A based on third reception signal S_3 illustrated in FIG. **4**. For example, second control unit **201**B may output second control signal Sc_2 in the case of detecting an input of third reception signal S_3. In this case, second control signal Sc_2 is output from second control unit **201**B in a case where first frequency signal Sf_1 or second frequency signal Sf_2 input to activation signal detector **201**C is at a predetermined level (amplitude) or more.

In FIG. **4**, the level (amplitude) of a signal of transmission data **501** is preferably equal to or greater than the signal level (amplitude) of activation signal **504**. In addition, the level (amplitude) of first frequency signal Sf_1 transmitted from signal transmission unit **102**B is preferably equal to the level (amplitude) of second frequency signal Sf_2. With this configuration, activation signal detector **201**C can also output third reception signal S_3 based on transmission data **501**. Thus, even in a case where activation signal **504** cannot be received, second control unit **201**B can activate signal reception unit **201**A based on transmission data **501**. Here, the term "activation signal **504** cannot be received" is supposed to be, for example, a case where an instruction signal from another equipment has the same frequency as that of activation signal **504** so that an interference occurs in the activation signal.

Second control unit **201**B is not limited to the configuration in which second control signal Sc_2 is output based on the level (amplitude) of first frequency signal Sf_1 or second frequency signal Sf_2, and may have a configuration in which second control signal Sc_2 is output based on a signal length of first frequency signal Sf_1 or second frequency signal Sf_2. A signal length of third reception signal S_3 illustrated in FIG. **4** is determined based on a length from when input first frequency signal Sf_1 or second frequency signal Sf_2 reaches a specific level (amplitude) or more to when input first frequency signal Sf_1 or second frequency signal Sf_2 reaches a level less than the specific level (amplitude). In view of this, second control unit **201**B may activate signal reception unit **201**A in a case where the signal length of third reception signal S_3 illustrated in FIG. **4** is determined to be longer than a predetermined time.

In this case, a signal length of transmission data **501** is preferably equal to or greater than a signal length of activation signal **504**. That is, the signal length of transmission data **501** is preferably equal to or greater than the signal length of third reception signal S_3. With this configuration, activation signal detector **201**C can also activate signal reception unit **201**A based on transmission data **501**. Thus, even in a case where activation signal detector **201**C fails to detect activation signal **504**, signal reception unit **201**A can be activated based on transmission data **501**.

With the foregoing configuration, second control unit **201**B outputs second control signal Sc_2 to signal reception unit **201**A to activate signal reception unit **201**A, in response to an input of third reception signal S_3. In addition, second control unit **201**B outputs third control signal Sc_3 to switch **201**G so that first frequency signal Sf_1 or second frequency signal Sf_2 is supplied to signal reception unit **201**A. With this operation, signal reception unit **201**A comes to be a state in which signal reception unit **201**A can receive first frequency signal Sf_1 or second frequency signal Sf_2.

First control unit **102**A outputs transmission data **501** to signal transmission unit **102**B after a lapse of a predetermined time from an output of activation signal **504**. Signal transmission unit **102**B converts transmission data **501** to first frequency signal Sf_1 with a first frequency and second frequency signal Sf_2 with a second frequency, and transmits the converted signals to signal reception unit **201**A. In a case where correct identification signal **503** is detected in first reception signal S_1 or second reception signal S_2, second control unit **201**B outputs first control signal Sc_1 in accordance with instruction signal **502**. In a case where transmission data **501** is correctly received in the foregoing manner, second communication device **201** transmits reply signal **505** from reply unit **201**E to third receiver **102**D. In addition, second control unit **201**B changes or stops an output of second control signal Sc_2 to stop an operation of signal reception unit **201**A.

A case where the first communication fails will now be described. FIG. **5** is a timing chart concerning another operation of communication system **24**. In a case where no reply signal **505** is detected in a predetermined time (first time) after output of transmission data **501** illustrated in FIG. **5** to signal transmission unit **102**B, first control unit **102**A outputs transmission data **501** again to signal transmission unit **102**B as first retransmission data. First control unit **102**A repeats this operation until reply signal **505** is detected.

FIG. **5** illustrates a case where an interference with, for example, another communication system occurs twice and transmission is successful in re-retransmission at the third time. In the case where an interference occurs, there is a possibility that second control unit **201**B fails to detect that each of first reception signal S_1 and second reception signal S_2 includes identification signal **503**. If second control unit **201**B fails to detect identification signal **503**, first communication device **102** may convert transmission data **501** illustrated in FIG. **3** to first frequency signal Sf_{12} and second frequency signal Sf_{22} and transmits the converted signal as retransmission data, after a lapse of a specific time (standby time) since the predetermined time (first time) has elapsed. The standby time herein refers to first standby time T**1** or second standby time T**2** in FIG. **5**. In FIG. **5**, the length of first standby time T**1** differs from the length of second standby time T**2**. Alternatively, the length of first standby time T**1** may be equal to the length of second standby time T**2**. The start point of the standby time is, for example, a point of time when communication between first communication device **102** and second communication device **201** is completed. Note that the start point of the standby time is not limited to the time of completion of communication, and may be a point of time when first control unit **102**A receives instruction signal **502** from input unit **101** or when first control unit **102**A outputs transmission data **501** to signal transmission unit **102**B. Alternatively, the start point may be a point of time when signal transmission unit **102**B transmits first frequency signal Sf_1 or when signal transmission unit **102**B transmits second frequency signal Sf_2.

With the foregoing configuration, as illustrated in FIG. **2**, first communication device **102** and second communication device **201** communicate with each other using transmission data **501** illustrated in FIG. **5** at first frequency f_1 and second frequency f_2. For example, first communication device **102** can transmit transmission data **501** illustrated in FIG. **5** at first frequency f_1 and also transmit the data at second frequency f_2. In this manner, since first communication device **102** can transmit transmission data **501** at a plurality of frequencies, occurrence of an interference with another communication system can be suppressed. That is, in the present embodiment, it is sufficient to perform transmission without interference in at least one of a plurality of frequencies. Thus, unlike a conventional technique, the standby time does not need to be set at random so as to avoid interference. Since the standby time can be set at a predetermined time, not at random, the standby time can be shortened. Since the time during which signal reception unit **201**A performs a reception operation can be shortened, power consumption of signal reception unit **201**A can be reduced. Thus, operating device **22** can also operate with self-contained power generator **102**E that generates only a small amount of electric power.

The predetermined time (standby time) may differ among remote operating devices **21**. In other words, remote operating device **21**A and remote operating device **21**B illustrated in FIG. **1** preferably have different standby times. That is, each of remote operating devices **21** preferably has a unique time as a standby time. Remote control device **21** has a unique identification number, and identification signal **503** corresponds to the identification number. Thus, each remote operating device **21** preferably has a standby time based on the identification number. Since each of a plurality of remote operating devices **21** has a unique standby time, even if remote operating devices **21** operate at the same time in a first transmission, the probability that multiple remote operating devices **21** operate at the same time in a second transmission or a subsequent transmission decreases. That is, although interference occurs only in a case where signals are transmitted from a plurality of transmitters at the same timing and at the same frequency, a shift in timing at second and subsequent transmissions can suppress occurrence of interference.

First control unit **102**A may have a maximum number of outputs of transmission data **501**. For example, in a case where the maximum number is three, first control unit **102**A repeatedly outputs transmission data **501** three times at most, as illustrated in FIG. **5**. Then, after outputting transmission data **501** three times, first control unit **102**A stops the output of transmission data **501**. Thus, first control unit **102**A ignores or does not accept instruction signal **502** output from input unit **101** in a predetermined time. Specifically, in a case where communication is successfully performed before the number of outputs reaches the maximum number, first control unit **102**A does not accept instruction signal **502** until communication is successfully performed. In a case where communication is not successfully performed even when the number of outputs reaches the maximum number, first control unit **102**A does not accept instruction signal **502** until transmission at the maximum number is completed. With this configuration, second control unit **201**B can suppress erroneous determination of instruction signal **502**.

Transmission data **501** preferably includes operation number signal **506** illustrated in FIG. **3**, in accordance with the number of operations of an operator with input unit **101**. With this configuration, second control unit **201**B can detect the number of operations.

As illustrated in FIG. **5**, in a case where no reply signal **505** is detected in a predetermined time after output of retransmission data **501** to signal transmission unit **102**B, first control unit **102**A may output first retransmission data again to signal transmission unit **102**B after a lapse of first standby time T**1**. First control unit **102**A preferably sets first standby time T**1** depending on identification signal **503**. With this configuration, first standby time T**1** can be set at various times depending on the identification signal. Thus, an interval in which signal transmission unit **102**B transmits transmission data **501** can be shifted from an interval in which another communication system transmits another transmission data. Accordingly, occurrence of interference with another communication device can be suppressed.

Furthermore, as illustrated in FIG. **5**, in a case where no reply signal **505** is detected in a predetermined time after output of first retransmission data to signal transmission unit **102**B, first control unit **102**A may output transmission data **501** again to signal transmission unit **102**B illustrated in FIG. **2** as second retransmission data after a lapse of second standby time T**2**. As a result, signal transmission unit **102**B transmits first frequency signal Sf_{13} with a first frequency and second frequency signal Sf_{23}. In this case, first control unit **102**A preferably also sets second standby time T**2** in accordance with identification signal **503**. In first control unit **102**A, in a case where first standby time T**1** is long, second standby time T**2** may be short. In contrast, in first control unit **102**A, in a case where first standby time T**1** is short, second standby time T**2** may be long. That is, in first control unit **102**A, first standby time T**1** and second standby time T**2** may be set based on identification signal **503** in such a manner that first standby time T**1** and second standby time T**2** differ from each other.

With this configuration, each of first standby time T**1** and second standby time T**2** can be obtained with correction of a standard time using an identification number or identification signal **503** in first control unit **102**A. First standby time T**1** may be obtained by, for example, multiplying the standard time by the identification number or identification signal **503**. In this case, second standby time T**2** can be obtained by, for example, dividing the standard time by the identification number or identification signal **503**. Alternatively, first standby time T**1** may be obtained by dividing the standard time by the identification number or identification signal **503**. In this case, second standby time T**2** can be obtained by, for example, multiplying the standard time by the identification number or identification signal **503**. Alternatively, first standby time T**1** may be obtained by, for example, adding the identification number or identification signal **503** to the standard time. In this case, second standby time T**2** can be obtained by, for example, subtracting the identification number or identification signal **503** from the standard time. Alternatively, first standby time T**1** may be obtained by subtracting the identification number or identification signal **503** from the standard time. In this case, second standby time T**2** can be obtained by, for example, adding the identification number or identification signal **503** to the standard time. With the foregoing configuration, first standby time T**1** and second standby time T**2** can differ from each other so that occurrence of interference due to transmission from another communication system can be further suppressed.

FIG. **6** is an example of a block diagram of signal transmission unit **102**B. Signal transmission unit **102**B may include an instruction communication device $\mathbf{102}B_1$ for generating first frequency signal Sf_1 and an instruction communication device $\mathbf{102}B_2$ for generating second frequency signal Sf_2. A signal transmitter $\mathbf{102}B_3$ supplies a signal with a first frequency to instruction communication device $\mathbf{102}B_1$ and supplies a signal with a second frequency to instruction communication device $\mathbf{102}B_2$.

As described above, a first communication device according to the present disclosure can transmit transmission data in the first transmission at a first frequency and can transmit transmission data in second transmission at a second frequency. Thus, occurrence of interference with transmission of another communication system can be suppressed. In addition, a standby time can be set at a constant time, not at random. Thus, the standby time can be shortened. Since reception times of a first receiver and a second receiver can be shortened, power consumption of a second communication device can be reduced.

INDUSTRIAL APPLICABILITY

A communication system according to the present disclosure has advantages of suppressing occurrence of interference in communication and reducing power consumption, and is useful for, for example, equipment driven by a battery or a storage battery for operating an operation target wirelessly.

The invention claimed is:

1. A transmission device comprising:

a control unit that outputs transmission data; and

a signal transmission unit that receives the transmission data and converts the transmission data to a first frequency signal and a second frequency signal, the first frequency signal having a first frequency, the second frequency signal having a second frequency different from the first frequency, and

a receiver that receives a third frequency signal generated based on the transmission data, converts the third frequency signal to a reply receipt signal, and outputs the reply receipt signal to the control unit, the third frequency signal having a third frequency different from both of the first frequency and the second frequency, wherein:

the signal transmission unit is configured to:

first transmit a first signal having the first frequency;

transmit the first frequency signal after transmitting the first signal;

transmit a second signal having the first frequency after transmitting the first frequency signal; and

transmit the second frequency signal after transmitting the first frequency signal and before transmitting the second signal, and

a signal length of the first frequency signal is equal to a signal length of the first signal,

in a case where the reply receipt signal is not detected in a first time after output of the transmission data to the signal transmission unit, the first control unit outputs the transmission data again to the signal transmission unit as first retransmission data, and

in a case where the reply receipt signal is not detected in the first time, the control unit outputs the first retransmission data to the signal transmission unit after a lapse of a first standby time since the first time has elapsed.

2. The transmission device of claim **1**, wherein the signal transmission unit starts transmission of the second frequency signal after starting transmission of the first frequency signal.

3. The transmission device of claim **2**, wherein the signal transmission unit transmits the second frequency signal after completion of transmission of the first frequency signal.

4. The transmission device of claim **1**, wherein the signal transmission unit includes:

a first transmitter that transmits the first frequency signal, and

a second transmitter that transmits the second frequency signal.

5. The transmission device of claim **1**, wherein: the control unit includes an identification signal, and the control unit sets the first standby time based on the identification signal.

6. The transmission device of claim **1**, wherein in a case where the reply receipt signal is not detected in a second time after output of the first retransmission data to the signal transmission unit, the control unit outputs the transmission data again to the signal transmission unit as second retransmission data after a lapse of a second standby time since the second time has elapsed.

7. The transmission device of claim **6**, wherein the control unit sets the first standby time and the second standby time based on the identification signal in such a manner that the first standby time and the second standby time differ from each other.

8. The transmission device of claim **1**, wherein a signal length of the second frequency signal is equal to or greater than the signal length of the first signal.

9. The transmission device of claim **8**, wherein the signal length of the first frequency signal is equal to the signal length of the second frequency signal.

10. The transmission device of claim **1**, wherein the second frequency signal is one of a plurality of second frequency signals each having the second frequency.

11. The transmission device of claim **1**, further comprising:

an input unit that causes the transmission unit to output the transmission data; and

a power generator that generates electric power in response to an operation to the input unit and supplies the electric power to at least one of the control unit and the signal transmission unit.

12. The transmission device of claim **1**, further comprising:

an input unit that outputs an instruction signal to the control unit, wherein the first signal is a signal transmitted by the signal transmission unit firstly after the instruction signal is output to the control unit.

13. A reception device that receives signals transmitted from the transmission device of claim **1**, the reception device comprising:

a signal reception unit that:

receives the first signal, the second signal, the first frequency, and the second frequency signal which are transmitted from the transmission device,

outputs a first reception signal based on the first frequency signal, and

outputs a second reception signal based on the second frequency signal; and

another control unit that receives the first reception signal and the second reception signal, wherein

the signal reception unit is activated in response to one of the first frequency signal or the second frequency signal, and

the another control unit outputs a control signal in a case where at least one of the first reception signal or the second reception signal includes transmission data.

14. The reception device of claim **13**, further comprising:

an activation signal detector that outputs a third reception signal to the another control unit in a case where one of the first frequency signal or the second frequency signal has a predetermined amplitude or more, wherein:

the another control unit activates the signal reception unit based on the third reception signal.

15. The reception device of claim **14**, wherein the another control unit activates the signal reception unit in a case where a signal length of the third reception signal is a predetermined length or more.

16. The reception device of claim **15**, wherein a signal length of the transmission data is equal to or greater than the signal length of the third reception signal.

17. The reception device of claim **13**, wherein the signal reception unit includes a first receiver that receives the first frequency signal and outputs the first reception signal, and a second receiver that receives the second frequency signal and outputs the second reception signal.

18. The reception device of claim **13**, further comprising:

a reply unit; and

a filter that allows the first frequency signal and the second frequency signal to pass therethrough, wherein:

in a case where it is determined that at least one of the first reception signal or the second reception signal includes an identification signal, the control unit outputs a reply signal to the reply unit, and

the reply unit converts the reply signal to a third frequency signal having a frequency different from the frequency of the first frequency signal and the frequency of the second frequency signal, and

the filter attenuates the third frequency signal.

19. The reception device of claim **13**, wherein the signal reception unit is activated in response to any one of the first signal, the first frequency signal, and the second frequency signal.

20. A communication system comprising a transmission device and a reception device, wherein:

the transmission device includes:

a first control unit that outputs transmission data;

a signal transmission unit that receives the transmission data and converts the transmission data to a first frequency signal and a second frequency signal, the first frequency signal having a first frequency, the second frequency signal having a second frequency different from the first frequency; and

a receiver that receives a third frequency signal generated based on the transmission data, converts the third frequency signal to a reply receipt signal, and outputs the reply receipt signal to the first control unit, the third frequency signal having a third frequency different from both of the first frequency and the second frequency,

the signal transmission unit is configured to:

first transmit a first signal having the first frequency; and

transmit the first frequency signal after transmitting the first signal;

transmit a second signal having the first frequency after transmitting the first frequency signal; and

transmit the second frequency signal after transmitting the first frequency signal and before transmitting the second signal,

a signal length of the first frequency signal is equal to a signal length of the first signal,

in a case where the reply receipt signal is not detected in a first time after output of the transmission data to the signal transmission unit, the first control unit outputs the transmission data again to the signal transmission unit as first retransmission data, and

in a case where the reply receipt signal is not detected in the first time, the first control unit outputs the first retransmission data to the signal transmission unit after a lapse of a first standby time since the first time has elapsed,

the reception device includes:

a signal reception unit that receives the first signal, the second signal, the first frequency signal and the second frequency signal, outputs a first reception signal based on the first frequency signal, and outputs a second reception signal based on the second frequency signal, and

a second control unit that receives the first reception signal and the second reception signal,

wherein the second control unit outputs a first control signal in a case where at least one of the first reception signal or the second reception signal includes the transmission data.

21. The communication system of claim **20**, wherein the signal reception unit is activated in response to one of the first frequency signal or the second frequency signal.

22. The communication system of claim **20**, wherein the transmission device further includes:

an input unit that causes the transmission unit to output the transmission data; and

a power generator that generates electric power in response to an operation to the input unit and supplies the electric power to at least one of the control unit and the signal transmission unit.

23. The communication system of claim **20**, wherein:

the transmission device further includes an input unit that outputs an instruction signal to the control unit, and

the first signal is a signal transmitted by the signal transmission unit firstly after the instruction signal is output to the first control unit.

24. The communication system of claim **20**, wherein the signal transmission unit starts transmission of the second frequency signal after starting transmission of the first frequency signal.

25. The communication system of claim **20**, wherein the signal reception unit is activated in response to any one of the first signal, the first frequency signal, and the second frequency signal.

26. A remote operating device comprising an input unit, a transmission device, a reception device and a controlled unit, wherein:

the transmission device includes:

a first control unit that outputs transmission data based on an instruction signal input from the input unit;

a signal transmission unit that receives the transmission data and converts the transmission data to a first frequency signal and a second frequency signal, the first frequency signal having a first frequency, the second frequency signal having a second frequency different from the first frequency; and

a receiver that receives a third frequency signal generated based on the transmission data, converts the third frequency signal to a reply receipt signal, and outputs the reply receipt signal to the first control unit, the third frequency signal having a third frequency different from both of the first frequency and the second frequency,

the signal transmission unit is configured to:

first transmit a first signal having the first frequency; and

transmit the first frequency signal after transmitting the first signal;

transmit a second signal having the first frequency after transmitting the first frequency signal; and

transmit the second frequency signal after transmitting the first frequency signal and before transmitting the second signal,

a signal length of the first frequency signal is equal td a signal length of the first signal,

in a case where the reply receipt signal is not detected in a first time after output of the transmission data to the signal transmission unit, the first control unit outputs the transmission data again to the signal transmission unit as first retransmission data, and

in a case where the reply receipt signal is not detected in the first time, the first control unit outputs the first retransmission data to the signal transmission unit after a lapse of a first standby time since the first time has elapsed,

the reception device includes:

a signal reception unit that receives the first frequency signal, the second signal, and the second frequency signal, outputs a first reception signal based on the first frequency signal, and outputs a second reception signal based on the second frequency signal; and

a second control unit that receives the first reception signal and the second reception signal,

the second control unit outputs the first control signal to the controlled unit in a case where at least one of the first reception signal or the second reception signal includes the transmission data.

27. The remote operating device of claim **26**, wherein the first signal is a signal transmitted by the signal transmission unit firstly after the instruction signal is output to the first control unit.

28. The remote operating device of claim **26**, wherein the signal reception unit is activated in response to one of the first frequency signal or the second frequency signal.

29. The remote operating device of claim **26**, wherein the signal transmission unit starts transmission of the second frequency signal after starting transmission of the first frequency signal.

30. The remote operating device of claim **26**, wherein the signal reception unit is activated in response to any one of the first signal, the first frequency signal, and the second frequency signal.

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